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ATTENUATION VARIATION OBTAINED WITH TRAINING WHEN UTILIZING AN IN-THE-EAR HEARING PROTECTIVE DEVICE

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By

Jerod L. Goldstein

Barbara Murphy

HUMAN TOLERANCE AND SURVIVABILITY DIVISON

Biomedical Tolerance

March 1980

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U.S. ARMY AEROMEDICAL RESEARCH LABORATORY

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This study attempted to determine the importance of training in the use of a specific hearing protective device, the E.A.R. earplug, which is considered a universal fit hearing protective device. The results of the study indicated that training in the use of the E.A.R. earplug is important and must be continually emphasized to provide maximal attenuation with the E.A.R. earplug.

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INTRODUCTION

The need to provide noise attenuating devices for protection of US Army personnel and workers in noise hazardous environments has been recognized for many years. The ANSI Standard S3.19-1974 and its predecessor, USA Standard Z24.22-1957, outline procedures designed to evaluate sound attenuation provided by hearing protective devices. Within the S3.19-1974 Standard, two methods of fitting an in-the-ear hearing protective device are allowed. One is "subject fit" and the other is "experimenter fit." Exact procedures and differences using these two procedures are outlined in paragraph 3.3.3.1 of the referenced 1974 ANSI Standard.

While either of the two published procedures have been determined acceptable, significant differences in attenuation scores were obtained with these two methods. This difference in attenuation scores with ten experienced subjects posed a potential problem which may be experienced by the "average soldier" who does not receive the close supervision provided in the laboratory environment. Therefore, when used by an inexperienced soldier, the attenuation provided by an earplug might differ significantly from the attenuation expected.

Padilla (1976) developed a field method of measuring earplug attenuation under a circumaural earmuff and found that experienced users of the in-the-ear hearing protective device obtained less attenuation than the manufacturer's specifications had indicated. Regan (1977) and Edwards, et al. (1978), in separate studies with a variety of in-the-ear hearing protective devices, found similar results of poorer attenuation than the manufacturer had indicated. Edwards, et al., also noted that workers often wore the wrong size earplugs or improperly inserted the earplugs.

Every soldier has access to earplugs, but he may not have access to supervised fitting and instructions in the use of the earplug. The E-A-R earplug is provided with fitting instructions (Appendix A) which require specific procedures to be utilized to obtain specified attenuation. Other in-the-ear hearing protective devices, such as the single flange and triple flange earplugs do not have any insertion instructions provided with them. Therefore, it is important to know what amount of attenuation is obtained for the untrained person as well as the trained person and compare these results to the "average soldier" in the field.

The specific experimental questions were (1) does the type of training the subject receives significantly affect the real-ear attenuation provided by the E-A-R earplug, and (2) does the "average" soldier obtain significantly different real-ear attenuation with the E-A-R earplug from the trained subject or from the "experimenter fit" subject.

METHODS

Thirty young adult male and female subjects participated in the study (OTSG 1978). Twenty subjects, 8 male and 12 female, were naive subjects having no prior experience with the E-A-R earplug. The remaining 10 male subjects were US Army soldiers who were using the E-A-R earplugs on a recurring basis during their normal military duties.

Each subject received a hearing threshold evaluation to determine if he/she met the ANSI Standards S3.19-1974, paragraph 3.2.1 and 3.2.2. Each subject was trained and exposed to the measurement conditions to insure familiarity with the testing procedures. Each subject experienced the test procedure with and without attenuation using commercially available earmuffs. The training session was approximately 2 hours in duration and the subjects were given guidance and reinforcement to perform the threshold tracking task. The test conditions using the E-A-R earplug were conducted during the second session.

Group I consisted of ten naive subjects. They were provided a pair of E-A-R earplugs with the manufacturer's instructions (see Appendix A) and asked to insert the device as indicated. They were then tested in accordance with the USA Standard Z24.22-1957 without access to instructions on repeat trials.

Group II also consisted of ten naive subjects. They were provided a pair of E-A-R earplugs with the manufacturer's instructions as well as approximately 10 minutes of individualized training with the E-A-R earplug. The training consisted of having the subjects study two US Army Environmental Hygiene Agency posters for insertion and utilization of earplugs. Additional instructions to insure adequate orientation and education were provided (see Appendix A for both sets of instructions). Upon completion of the training, they were then tested in accordance with USA Standard Z24.22-1957 without access to the fitting instruction on repeat trials.

Group III consisted of 10 US military personnel who were experienced users of the E-A-R earplug. These subjects were given a new pair of E-A-R earplugs but not the accompanying manufacturer's instructions. This test condition provided a somewhat realistic field usage situation where the soldier takes his E-A-R earplugs from the plastic carrying case and inserts them in his ears. Attenuation testing was conducted in accordance with USA Standard Z24.22-1957.

The real-ear attenuation was determined by taking the difference between the threshold values obtained with and without the hearing protector. A free-field unattenuated reference threshold was obtained with the subject facing a loudspeaker with his head fixed on a rest

that maintained a constant head position. Next a threshold measurement was taken under identical conditions with earplugs fitted to the subject. This set of measurements was repeated three times for a total of six measures. The mean response of the three measures is the real-ear attenuation. The subject controlled a recording attenuator which varied the intensity of the test frequency in a Békésy type presentation.

Group IV consisted of data obtained in a separate study performed in this laboratory by the same tester using an "experimenter fit" procedure as described in ANSI Standard S.3-19-1974 but the attenuation testing was conducted in accordance with USA Standard Z24-22-1957.

MATERIALS

In accordance with the USA Z24.22-1957 standard, there was no audible ambient noise during the period of measurement. See Appendix B for ambient noise levels and sound pressure level gradients of the Industrial Acoustics Company Model 1285-A. Tables in Appendix B are from USAARL Letter Report, 5 December 1969.

The test equipment consisted of the instrumentation shown in Figure 1. The tones were generated by a Fluke Synthesized Signal Generator Model 6010A. The output of the generator was connected to the input of a Grason-Stadler 1287-B electronic switch. The test tones were interrupted with a 50% duty cycle and with off and on durations of approximately 370 milliseconds, which simulates the interruption rate of a laboratory audiometer. The rise and decay times of the switch were 40 milliseconds each. The output of the electronic switch was connected to the input of a Grason-Stadler Model 1288 power amplifier. The power amplifier output was connected to a Grason-Stadler 1293 (10 ohm) step attenuator which was fed into a Grason-Stadler E-3262A recording attenuator.

The Grason-Stadler 1293 step attenuator provided the experimenter with a calibrated control of test tone levels for checking the subject's reliability. Also, it was used to control the sound pressure levels of the stimuli for subjects with extremely low thresholds and for increasing sound pressure when high efficiency devices were tested. The Grason-Stadler E-3262A recording attenuator controlled the output level of the Altec 605B 15-inch loudspeaker and recorded the subject's response. The recording attenuator was provided with a subject's photoelectric clickless type control switch and a second control switch which could be operated by the experimenter. The experimenters' switch had facilities for changing direction, stopping the attenuator and overriding the subject's control.

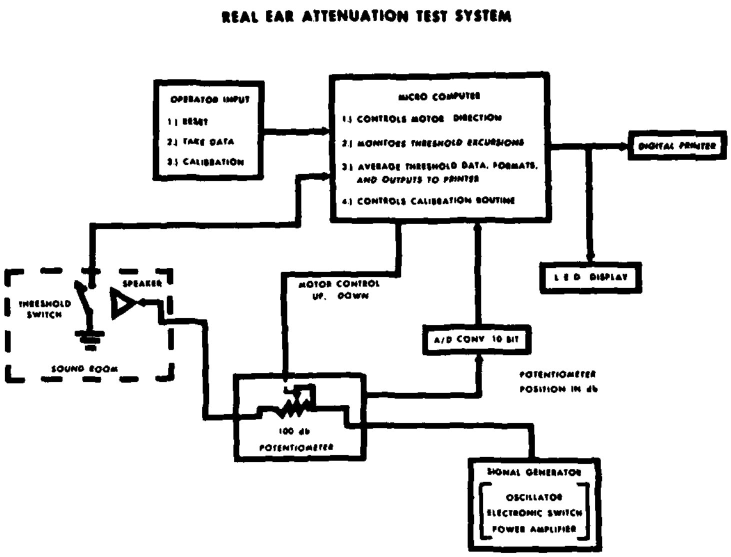

FIGURE 1. Real-Ear Attenuation Test System

The loudspeaker could deliver a sound field at the test frequencies such that the sound pressure level at the listener's position could vary from a maximum of 85 dB above 20μPa to a level below audibility. The voltage input to the speaker was calibrated at the beginning of each test with a Hewlett-Packard 3400A RMS voltmeter.

The test frequencies were pure tones of the following frequencies: 75 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz, and 8 kHz.

RESULTS

The results of this study indicate that the information and training given to Groups I and II provided better real-ear attenuation than the "average soldier," Group III, obtained with the E-A-R earplug. The "experimenter fit," Group IV, performed the best of all of the groups evaluated under laboratory controlled conditions.

Table 1 presents the means, standard deviations, medians, and ranges of scores for Groups I, II, III, and IV. Figure 2 graphically presents the mean real-ear attenuation scores for all four groups. It can be seen that Group IV provided the best overall attenuation and that the three remaining groups provided less real-ear attenuation.

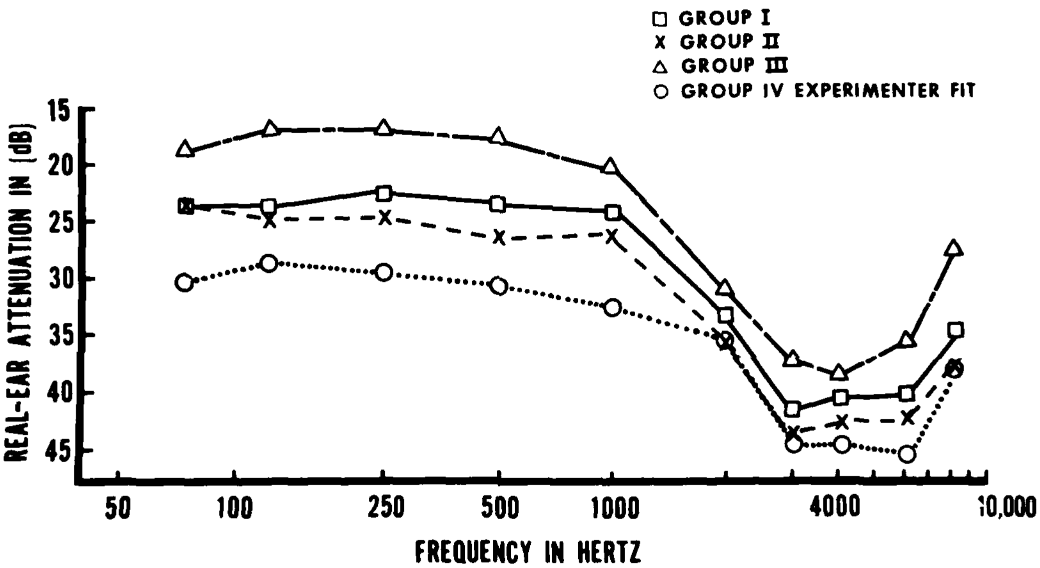

FIGURE 2. Mean real-ear attenuation score for the training Groups I, II, III, and "Experimenter Fit," Group IV.*

*Group I: Manufacturer's instructions
Group II: Manufacturer's instructions plus posters
Group III: Experienced military user personnel
Group IV: "Experimenter Fit"

Table 2 presents a three-way analysis of variance with repeated measures for Groups I, II, III, and IV (Winer 1962). It can be noted that a significant main effect was found for training groups (G) and frequency (F) at the point .001 level or higher.

TABLE 1

MEAN, STANDARD DEVIATION, MEDIAN, AND RANGE OF SCORE FOR FOUR GROUPS

		Test Frequencies in Hertz									
		75	125	250	500	1K	2K	3K	4K	6K	8K
Group I	Mean	23.7	23.5	22.8	23.4	24.2	33.3	41.8	40.7	40.2	34.4
	S.D.	7.0	7.8	7.4	8.0	6.5	5.1	7.4	5.7	8.3	10.9
	Median	24.2	23.0	23.0	21.8	23.4	33.2	42.8	41.4	42.7	31.2
	Range	6.7-38.1	6.9-41.7	6.8-42.3	11.4-42.8	13.0-41.6	20.0-44.4	24.5-54.4	29.5-50.1	19.8-51.5	14.4-60.4
		31.4	34.8	35.5	31.4	28.6	24.4	29.9	20.5	31.7	46.
Group II	Mean	23.5	24.7	24.5	26.5	26.3	36.1	43.7	42.4	42.6	37.4
	S.D.	7.8	5.8	5.4	5.3	6.6	5.0	6.2	6.2	6.4	7.7
	Median	24.1	24.5	23.7	26.1	25.2	35.2	44.2	42.5	43.7	39.1
	Range	4.5-35.4	11.1-34.3	15.8-36.1	13.0-36.5	12.6-41.8	25.7-46.6	32.6-52.1	29.1-53.4	23.1-56.3	22.9-49.7
		30.9	23.2	14.8	23.5	29.2	20.9	19.5	24.3	33.2	26.
Group III	Mean	18.4	16.9	17.0	17.4	20.1	30.9	37.3	38.4	35.6	27.7
	S.D.	8.8	8.8	8.2	7.0	6.8	6.5	6.6	6.2	9.5	10.2
	Median	19.9	16.0	16.5	17.3	19.8	31.0	37.8	39.9	34.2	29.4
	Range	-.3-35.6	2.0-35.6	-.9-36.5	0.0-32.1	5.4-39.0	11.0-42.4	23.0-52.7	24.6-51.9	23.3-57.0	2.1-44.6
		35.3	33.6	37.4	32.1	33.6	31.4	29.7	27.3	33.7	42.5
Group IV (Exp fit)	Mean	30.3	28.8	29.8	30.8	32.6	35.5	44.8	44.9	45.9	37.8
	S.D.	6.6	5.8	6.2	7.0	7.1	6.1	5.1	4.4	5.4	8.0
	Median	31.4	27.8	31.7	30.5	32.0	34.0	44.4	45.8	47.4	37.3
	Range	17.9-42.3	20.3-37.4	18.6-39.5	16.2-43.9	19.0-49.3	24.8-54.0	34.7-56.0	35.7-52.4	37.6-57.4	22.6-49.8

Each group consisted of 10 subjects tested three times each for a total of 30 tests.

TABLE 2

THREE-WAY ANALYSIS OF VARIANCE

Training Groups I, II, III, and IV performance with the E-A-R Hearing Protector over three repeated measures by frequency in hertz.

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Prob. F Exceeded
Mean	11839.64062	1	11839.64062	1900.39941	0.000
G(TrainingGroup)	161.73178	3	53.91060	8.65328	0.000
Error	244.28287	36	6.23008		
T(Trial)	6.80962	2	3.40481	2.97086	0.058
TG	0.96750	6	0.16125	0.14070	0.990
Error	82.51686	72	1.14607		
F(TestFrequency)	696.33325	9	77.37036	150.62617	0.000
FG	17.59976	27	0.65184	1.26902	0.172
Error	166.42523	324	0.51366		
TF	3.37288	18	0.18738	1.44147	0.106
TFG	10.43242	54	0.19319	1.48617	0.016
Error	84.23590	648	0.12999		

Table 3 indicates paired comparison differences in overall real-ear attenuation using the Duncan's (1955) New Multiple Range Test. These results indicate Groups I and II performed significantly better than Group III, but Group IV was significantly better than Groups III and I. Group IV was not found to be significantly different from Group II. Figure 3 graphically indicates the location of the mean real-ear attenuation scores by trials and training groups. A progressive reduction in overall attenuation was observed from Trial 1 to Trial 2 or 3.

TABLE 3

DUNCAN'S NEW MULTIPLE RANGE TEST WITH ALL FOUR GROUPS AND REPEATED MEASURES

Paired Groups	Finding	Significance
I X II	1.44	NS
I X III	3.52	X
I X IV	3.89	X
II X III	4.96	XX
II X IV	2.45	NS
III X IV	7.41	XXX

Significant level:
NS - Not significant at .05 level
X - Significant at .05 level
XX - Significant at 0.01 level
XXX - Significant at 0.001 level

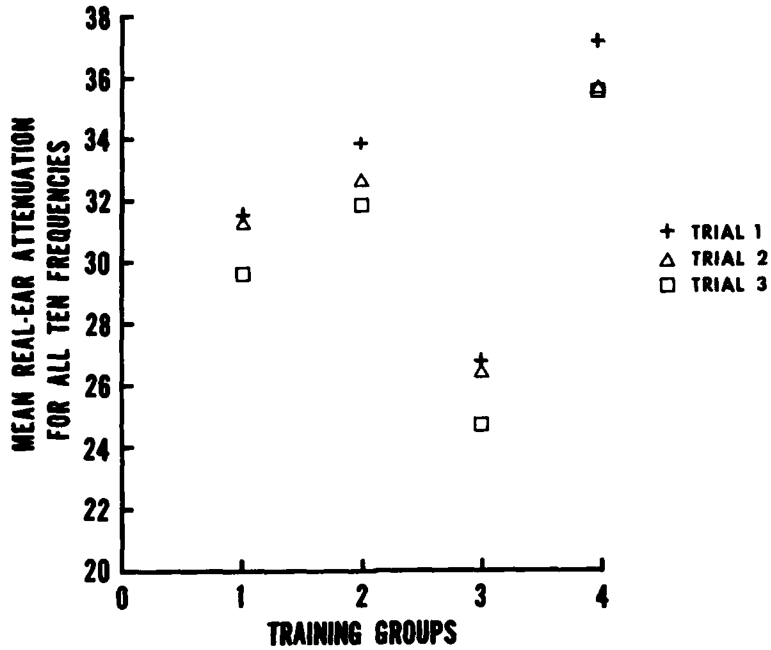

FIGURE 3. Mean real-ear attenuation score by trials and training Groups I, II, III, and the "Experimenter Fit," Group IV.

DISCUSSION

Real-ear attenuation is considered the mean attenuation value of 10 individuals tested three times each by the standard method (USA Z24-22.1957). Therefore, the individual differences which occur in each trial are averaged out and are not considered of importance. Specifically, variations in the hearing threshold as great as 6 dB are acceptable within the three tests, and individual variations of either the subject or experimenter in fitting the device are introduced during each seating of the in-the-ear protective device.

Real-ear attenuation is a frequency dependent measure. That is, most hearing protective devices provide greater protection for the higher frequencies than the lower frequencies. Statistical evaluation

of real-ear attenuation is influenced significantly because of this frequency dependence. Table 1 and Figure 3 can be used to observe the above discussed variations.

The three-way interaction (trials, frequency, groups [TFG]) was not of concern in this evaluation in light of the above discussion. The significant main effect for training groups (G) indicated the influence training had on the real-ear attenuation which the subjects in this study obtained with the E-A-R earplug. For example, at 250 Hz, Group III, showed a mean score of 17 dB; whereas, Group II showed a mean score of 24.5 dB or a 7.5 dB difference. This difference in real-ear attenuation could result in insufficient noise protection for the wearer if the earplug were used by an improperly trained individual in a noise hazardous area exceeding 100 dB at 250 Hz.

Table 3 shows the paired comparisons between groups indicating "experimenter fit," Group IV, was approximated only if extensive training (Group II) was provided to the subject. If the subject was provided with only the manufacturers instructions (Group I), insufficient training was provided to have the subject closely approximate the "experimenter fit" (Group IV). These results support the findings of Padilla (1976), Regan (1977), and Edwards, et al. (1978).

The real-ear attenuation the "average soldiers" (Group III) obtained was not approximating Group I subjects (see Figure 2). This indicates that the training the "average soldier" received was not adequate or he did not retain the necessary information. During the 2 hours of testing for each of the subjects slight decreases in real-ear attenuation were observed from Trial I through Trial 2 and 3 (Figure 3). This may indicate continued reinforcement is necessary to obtain the best possible real-ear attenuation with the E-A-R earplug.

Training was found to decrease the variation in real-ear attenuation within subject groups. For example, in comparing Groups I, II, and III, Table 1, the standard deviations for Group II were smallest in 7 out of the 10 frequencies tested; whereas, 6 out of the 10 frequencies for Group III showed the largest standard deviations. When using the range of scores obtained in Table 1 similar group differences were found. For example, Group III had the widest range of scores in 7 out of the 10 frequencies tested compared to Group II whose range of scores were always smaller than Group I or Group II.

The lower frequencies, 75 Hz through 250 Hz and 8000 Hz, appear to have the largest standard deviations in all three groups. The lower frequency range contains noise hazards most commonly found in the military environment (i.e., tanks and aircraft). This combination of large variance in real-ear attenuation and a preponderance of low frequency

noise exposure results in an area of concern for hearing conservation purposes. It can be noted in Table 1 that Group II has the smallest standard deviations between Groups I through III. This indicates the benefit of training, and the increased protection provided to the wearer particularly in the low frequencies.

The above comments indicate that the more extensively trained individual shows greater real-ear attenuation, smaller variance in real-ear attenuation, and more closely approximates Group IV, the "experimenter fit" subjects.

CONCLUSION

The findings of this study indicate that training and the fitting instructions supplied by the manufacturer of the E-A-R earplug provide the wearer with inadequate attenuation compared to the laboratory fitting procedure. The "average soldier" does not appear to be retaining the training he may have received. Adequate noise attenuation requires reinforcement in the proper use of E-A-R hearing protective devices even if that reinforcement is carefully rereading the instructions provided by the manufacturer.

The attenuation characteristics provided by the laboratory controlled "experimenter fit" are the ideal amount of attenuation one might expect from the hearing protective device. The findings of this study indicate that the real-ear attenuation provided by the device is dependent on the training that the user has received and retains.

RECOMMENDATIONS

A copy of the fitting instruction should be developed for insertion into the plastic carrying case NSN 6515-00-137-6345 for the E-A-R Hearing Protective Device NSN 6515-00-137-6345.

Stronger emphasis should be placed on supervisors to insure that users of the E-A-R hearing protective device have read, and understand US Army Environmental Hygiene Agency posters pertaining to the use of this hearing protective device.

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Appendix A

INSTRUCTIONS USED FOR EXPERIMENTAL GROUPS I AND II

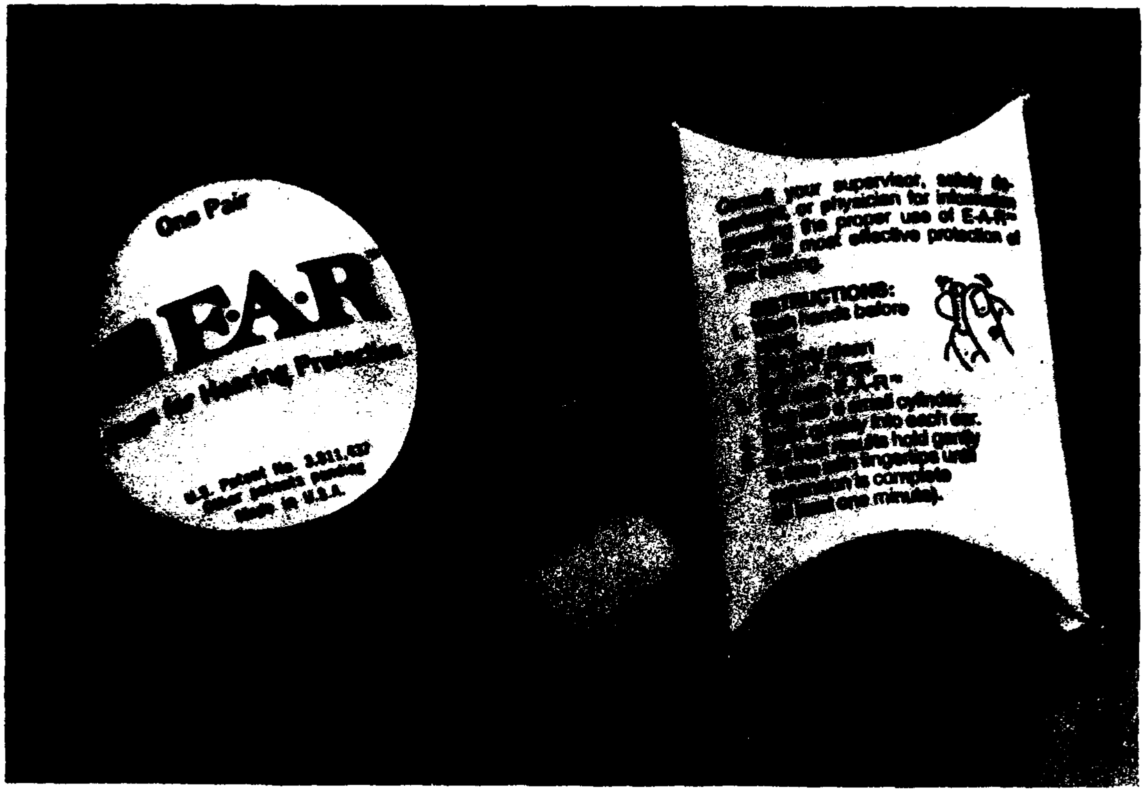

FIGURE A-1. Group I fitting instructions for E-A-R hearing protection device with additional instructions utilized with Group II.

EARPLUGS: GENERAL INFORMATION

1. Make the ear canal accessible by reaching over the head with opposite hand and pulling up and outward.

2. A good seal should be accompanied by a vacuum sensation (a back pressure). Also, your voice should sound muffled to you as if talking inside a barrel.

3. Plugs tend to work loose as a result of talking and chewing and must be reseated.

4. Even a small leak defeats the purpose of wearing plugs.

HAND-FORMED EARPLUGS

1. Yellow Foam Earplugs (NSN 6515-00-137-6345):

   a. Roll rather than squeeze each plug into as small a diameter as possible.

   b. Insert quickly into ear canal.

   c. Hold gently in place with fingertip for 1 minute until expansion is complete.

ADDITIONAL INSTRUCTIONS GIVEN VERBALLY DURING FITTING

1. Count from 1 - 5 aloud and indicate where in your head you hear your voice the loudest. It should be on the side with the earplug.

2. Insert remaining earplug.

3. Count from 1 - 5 again and indicate where you hear your voice. It should sound like it is in the middle of your head.

FIGURE A-2. INSTRUCTIONS

Appendix B

SOUND PRESSURE LEVELS

TABLE B-1

AMBIENT ACOUSTIC NOISE VALUES

Mean sound pressure level and standard deviation values in decibels (re 20μPa) for the USAARL Industrial Acoustics Company 1285-A Audiometric Room. Also shown are system noise data of the instrumentation used in measuring the acoustic noise.

1/3rd Octave Band	System Noise		Room Noise	
Center Frequencies in Hertz	Mean SPL Equiv.	Standard Deviation	Mean SPL	Standard Deviation
25	7.56	5.90	30.76	5.11
31.5	6.92	5.43	30.33	5.04
40	6.82	5.07	26.67	5.00
50	8.25	4.23	27.24	4.39
63	12.49	3.50	29.24	2.95
80	4.52	4.65	12.62	3.81
100	3.97	3.99	9.76	3.83
125	3.53	3.92	9.43	4.92
160	4.07	3.31	7.74	4.91
200	4.36	3.66	7.30	4.78
250	3.29	3.11	7.36	4.97
310	4.32	2.75	7.18	4.47
400	3.85	2.72	7.16	4.63
500	3.52	2.75	7.57	4.16
630	3.43	2.46	7.65	3.80
800	3.66	2.46	7.32	3.37
1000	1.50	2.04	6.11	2.07
1250	3.70	1.97	5.86	1.74
1600	6.32	1.75	6.09	1.92
2000	6.52	1.66	6.57	1.51
2500	7.26	1.60	6.61	1.60
3150	7.21	1.42	6.43	1.41
4000	7.06	1.37	6.34	1.29
5000	7.16	1.25	6.01	1.30
6300	7.07	1.15	6.08	1.29
8000	6.95	1.08	5.56	1.28
10000	6.37	1.01	5.16	1.27
12500	8.38	1.21	7.19	.98
16000	5.84	1.20	4.79	1.03
20000	5.47	1.27	4.53	.78
A	17.82	1.24	16.89	.84
B	17.78	1.23	24.26	2.94
C	21.08	1.72	36.68	4.10
Lin	23.67	1.59	37.91	3.66

TABLE B-2

SOUND PRESSURE LEVEL GRADIENTS CHARACTERISTICS
FRONT AND BEHIND NORMAL HEAD POSITION

The values are normal maximum sound pressure level output, in decibels (re 20μPa), from the calibrated instrumentation for testing real-ear attenuation. Data derived from measurements of ten test tones in the USAARL Industrial Acoustics Company 1285-A Audiometric Room.

Test Tones in Hz	Distance in Inches in Front of the Normal Head Position						Normal Head Position	Distance in Inches Behind the Normal Head Position					
	6"	5"	4"	3"	2"	1"	0	1"	2"	3"	4"	5"	6"
75	76.7	76.1	75.4	74.6	73.9	73.3	72.2	71.4	70.7	70.0	69.2	68.6	68.3
125	81.1	80.6	80.4	80.0	79.6	79.2	78.6	78.4	78.1	77.8	77.2	77.4	76.6
250	80.8	81.5	82.8	81.9	82.6	82.8	83.0	83.2	83.5	83.6	83.7	83.7	83.6
500	87.2	87.8	88.0	88.4	88.5	88.5	88.2	88.1	87.9	87.6	87.3	86.7	86.6
1000	86.0	84.6	83.4	83.7	84.7	86.0	86.6	86.5	85.8	84.6	83.3	82.4	82.5
2000	83.4	84.2	86.7	85.7	81.8	82.9	85.3	84.0	80.0	82.0	84.2	83.4	81.3
3000	82.6	83.8	83.4	83.6	85.3	82.0	82.6	80.2	78.8	83.3	79.5	84.4	85.8
4000	84.9	85.7	85.5	85.3	85.8	84.3	84.5	82.6	85.0	84.1	83.0	83.2	81.2
6000	78.0	81.4	80.6	77.8	79.0	81.2	82.8	72.6	77.8	80.8	82.0	75.0	77.8
8000	79.6	78.6	82.6	82.0	82.0	82.7	82.4	80.1	80.6	80.2	82.1	79.8	80.6

TABLE B-3

SOUND PRESSURE LEVEL GRADIENTS CHARACTERISTICS LEFT AND RIGHT OF NORMAL HEAD POSITION

The values are normal maximum sound pressure level output, in decibels (re 20μPa), from the calibrated instrumentation for testing real-ear attenuation. Data derived from measurements of ten test tones in the USAARL Industrial Acoustics Company 1285-A Audiometric Room.

Test Tones in Hz	Distance in Inches Left of the Normal Head Position						Normal Head Position	Distance in Inches Right of the Normal Head Position					
	6"	5"	4"	3"	2"	1"	0	1"	2"	3"	4"	5"	6"
75	71.6	71.6	71.7	71.7	72.1	72.0	72.3	72.3	72.3	72.4	72.4	72.5	72.3
125	78.1	78.2	78.3	78.4	78.6	78.5	78.6	78.8	78.9	78.9	79.0	79.0	79.0
250	82.4	82.5	82.6	82.7	82.8	82.8	82.9	83.0	83.1	83.1	83.1	83.1	83.2
500	88.2	88.5	88.7	88.9	89.0	88.9	88.9	88.6	88.4	87.9	87.5	87.0	86.4
1000	85.2	85.7	86.1	86.4	86.6	86.3	86.0	85.4	84.7	84.1	83.6	83.4	82.6
2000	83.0	83.2	83.7	84.5	84.7	84.9	85.2	85.1	85.1	84.7	83.3	82.6	84.4
3000	84.7	82.9	82.5	80.9	80.8	82.3	84.6	86.2	85.2	82.6	81.2	82.4	85.0
4000	82.4	82.0	82.4	81.6	82.4	82.8	83.8	84.6	82.6	80.5	82.3	84.3	82.5
6000	82.5	81.3	82.5	82.5	77.1	73.4	82.0	81.7	74.4	79.5	83.0	78.1	84.8
8000	76.4	81.7	79.1	81.7	83.6	83.1	83.1	84.7	79.9	83.7	76.2	81.5	74.2

TABLE B-4

SOUND PRESSURE LEVEL GRADIENTS CHARACTERISTICS
BELOW AND ABOVE NORMAL HEAD POSITION

The values are normal maximum sound pressure level output, in decibels (re 20μPa), from the calibrated instrumentation for testing real-ear attenuation. Data derived from measurements of ten test tones in the USAARL Industrial Acoustics Company 1285-A Audiometric Room.

Test Tones in Hz	Distance in Inches Below the Normal Head Position						Normal Head Position	Distance in Inches Above the Normal Head Position					
	6"	5"	4"	3"	2"	1"	0	1"	2"	3"	4"	5"	6"
75	70.5	70.6	70.8	71.2	71.4	71.6	71.8	71.7	71.8	72.1	72.3	72.3	72.5
125	77.2	77.6	77.8	77.8	78.0	78.2	78.5	78.5	78.7	79.0	79.2	79.4	79.6
250	84.3	84.3	84.1	83.6	83.4	82.9	82.8	82.6	82.4	82.0	81.8	81.6	81.5
500	89.4	89.3	89.1	89.0	88.9	88.6	88.6	88.5	88.5	88.6	88.6	88.7	88.8
1000	84.9	84.8	84.6	84.4	85.2	85.6	86.2	86.2	86.0	85.7	85.4	84.7	84.3
2000	85.6	85.8	85.5	84.6	84.0	84.2	84.8	84.9	84.8	84.4	84.0	84.4	85.0
3000	83.8	83.4	85.6	86.2	85.4	83.4	85.0	86.6	87.3	85.8	84.8	85.0	85.2
4000	84.1	85.0	84.8	85.4	87.8	87.0	85.2	85.4	84.6	84.4	84.8	84.0	82.1
6000	72.6	71.7	72.8	77.8	80.5	84.2	82.0	82.0	80.6	76.4	78.1	77.2	77.3
8000	79.2	78.0	77.9	81.1	81.8	83.4	83.6	84.2	85.1	82.4	84.4	81.1	83.0

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